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**Sagayama et al.**

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(54) **CONNECTOR**

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**H01R 12/78** (2011.01)

(52) **U.S. Cl.**  
CPC ..... **H01R 12/78** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01R 23/66; H01R 4/242; H01R 13/506;  
H01R 12/777; H01R 12/714; H01R 12/774;  
H01R 12/52; H01R 12/59  
USPC ..... 439/493–495, 67, 74, 492  
See application file for complete search history.

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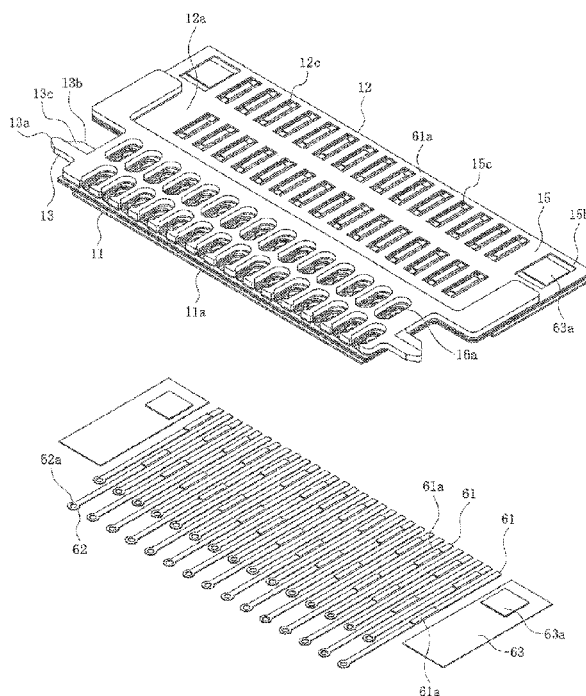
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(57) **ABSTRACT**

A connector is disclosed having a flat cable connecting portion connected to a flat cable and a flat mating portion mated with another connector. The connector comprises a plurality of terminals arranged on the mating portion for establishing contact with terminals on the other connector, a conductive connecting portion exposed on the cable connecting portion and connected to conductive trace connecting portions on the flat cable, and a plurality of wiring lines extending from the mating portion to the cable connecting portion, each one electrically connecting a terminal to the corresponding conductive trace connecting portion. The conductive connecting portion has a protrusion formed on the wiring lines. The upper surface of the protrusion is substantially the same height as one outer surface of the cable connecting portion.

**14 Claims, 11 Drawing Sheets**



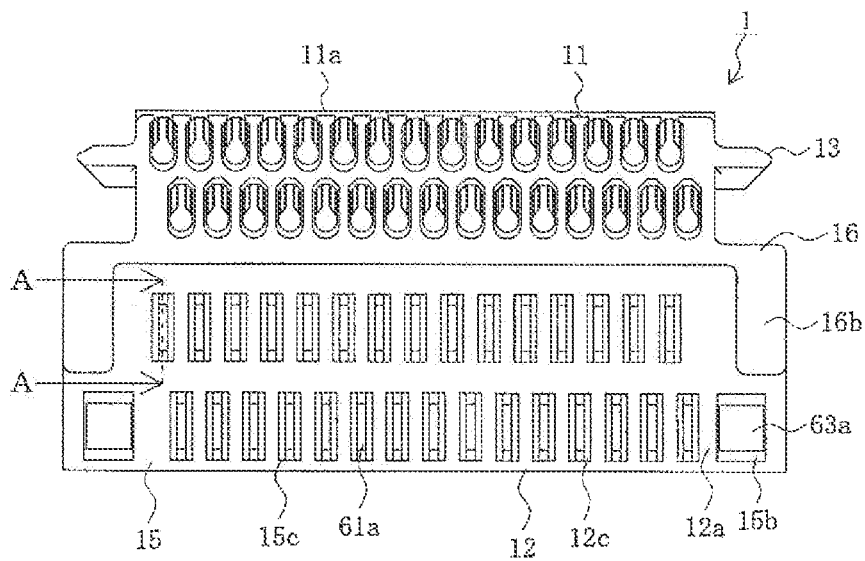


FIG. 1A

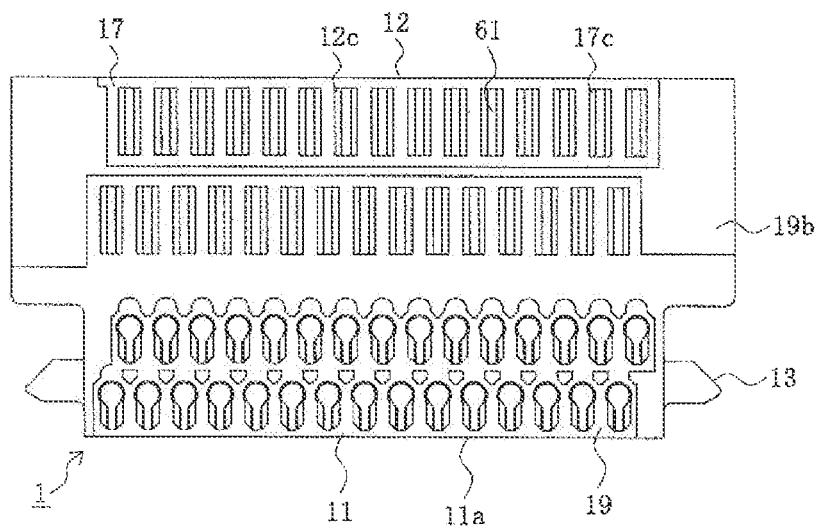


FIG. 1B

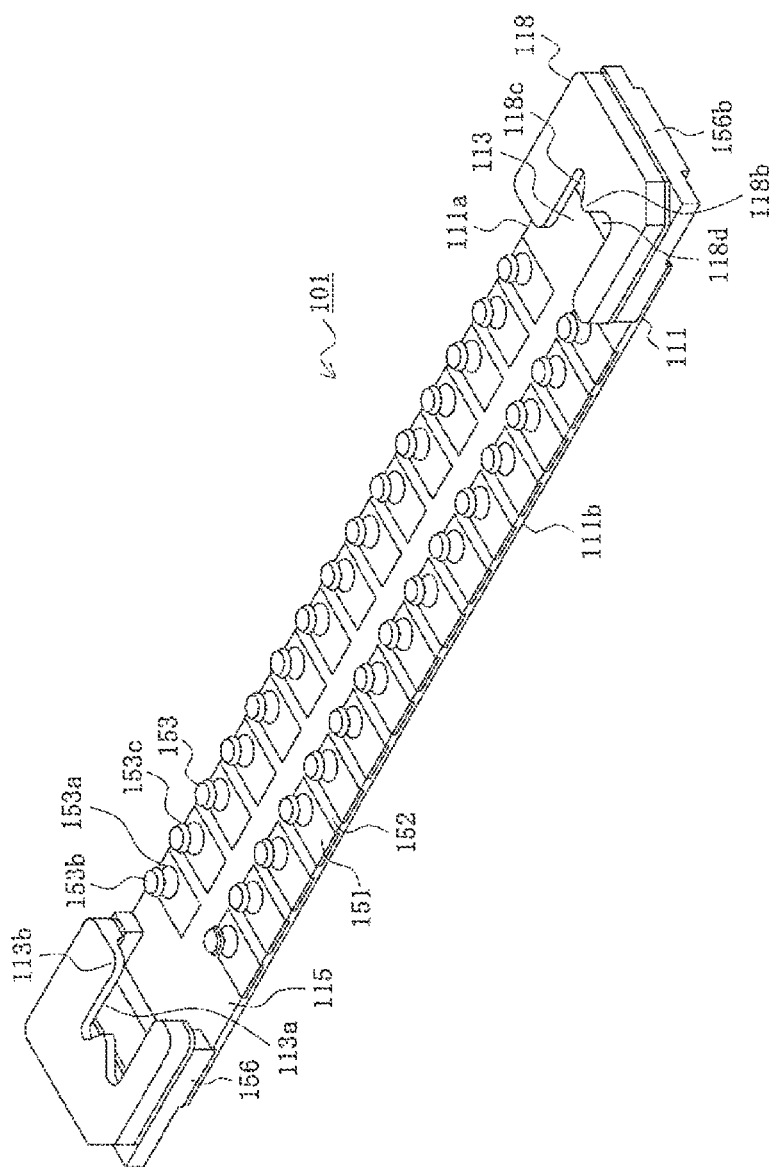


FIG. 2

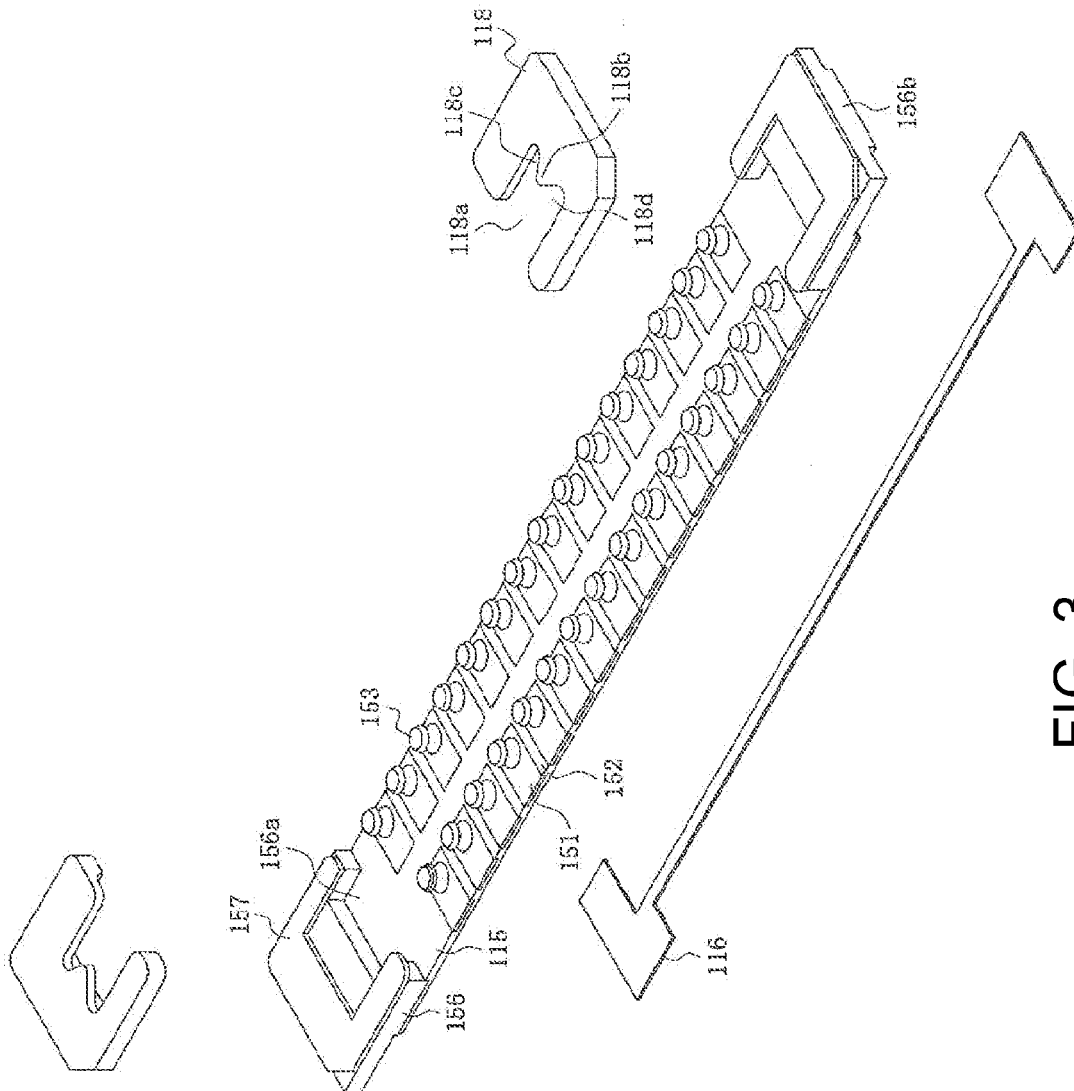


FIG. 3

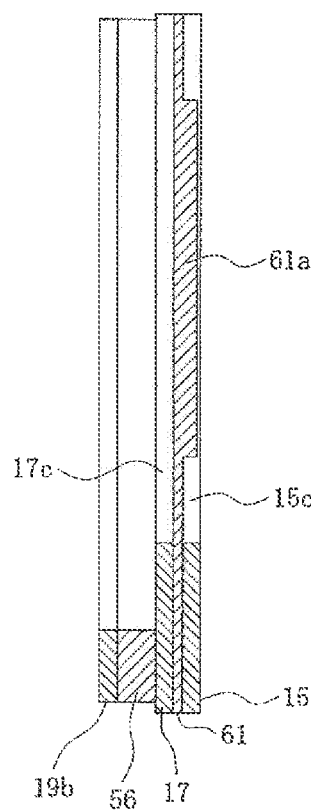


FIG. 4

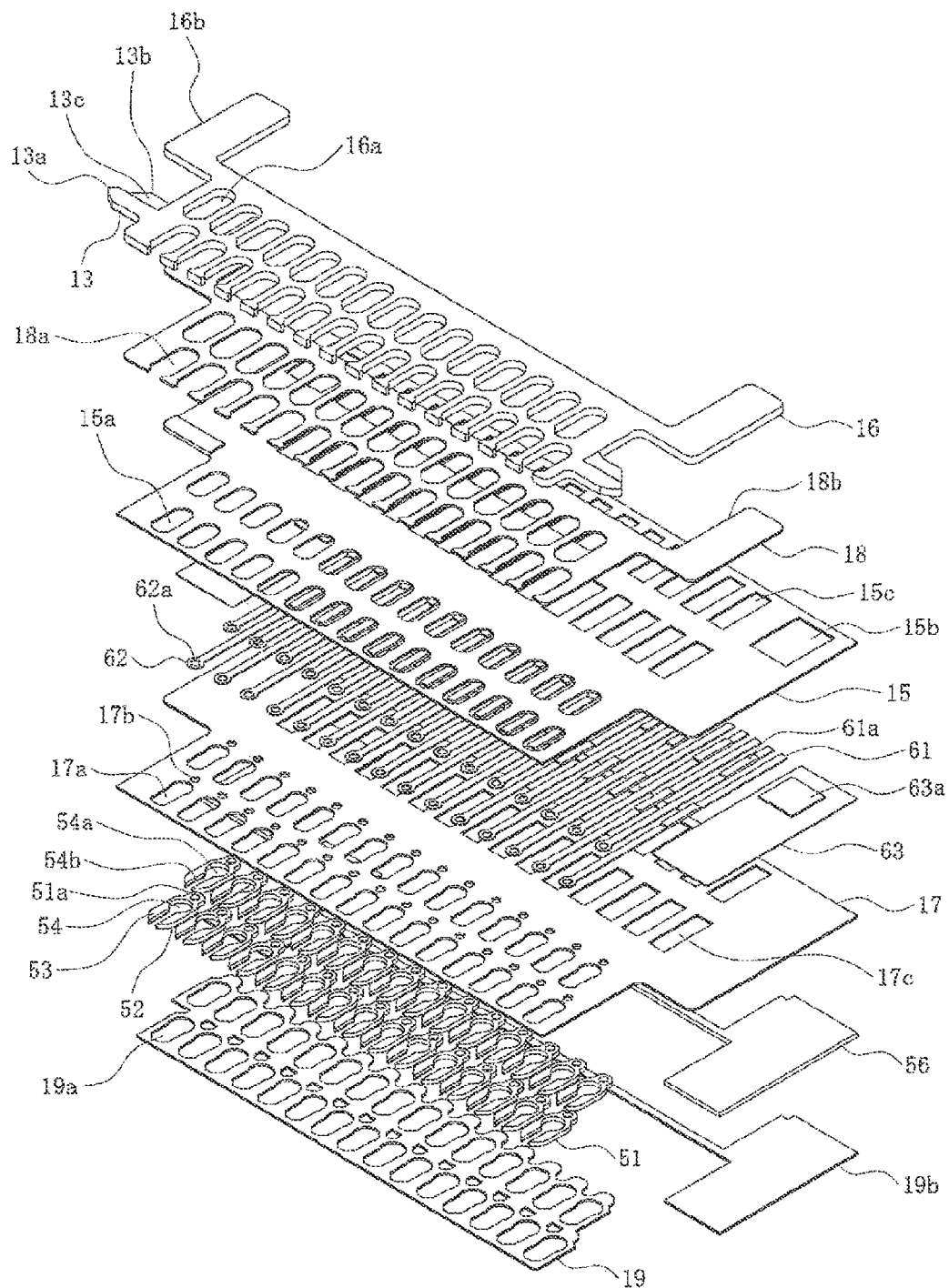


FIG. 5

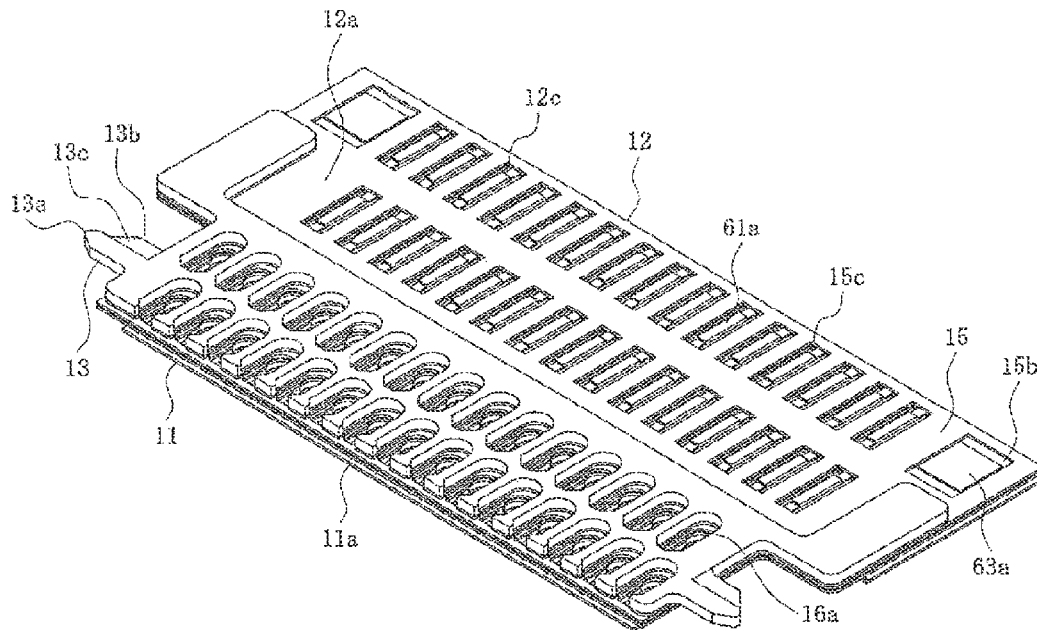
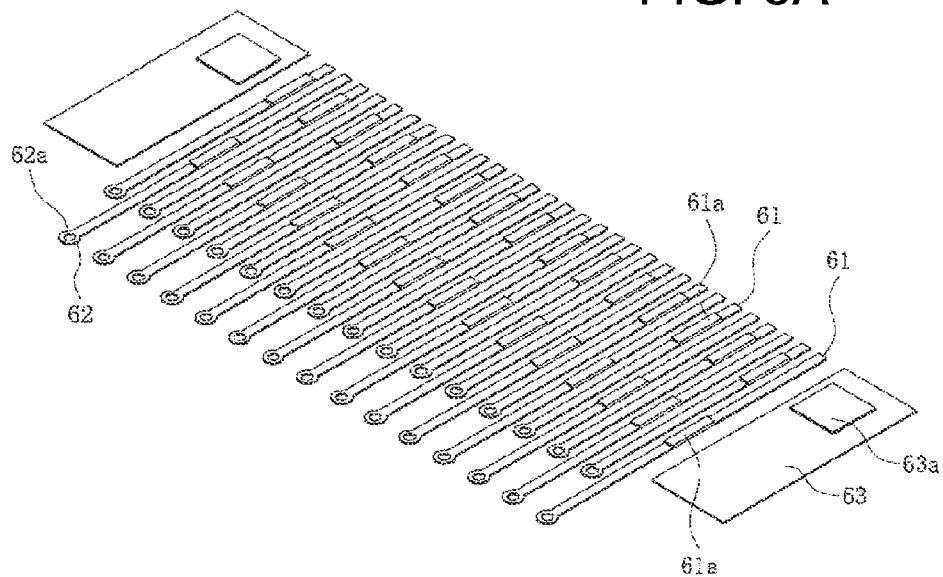


FIG. 6A



**FIG. 6B**

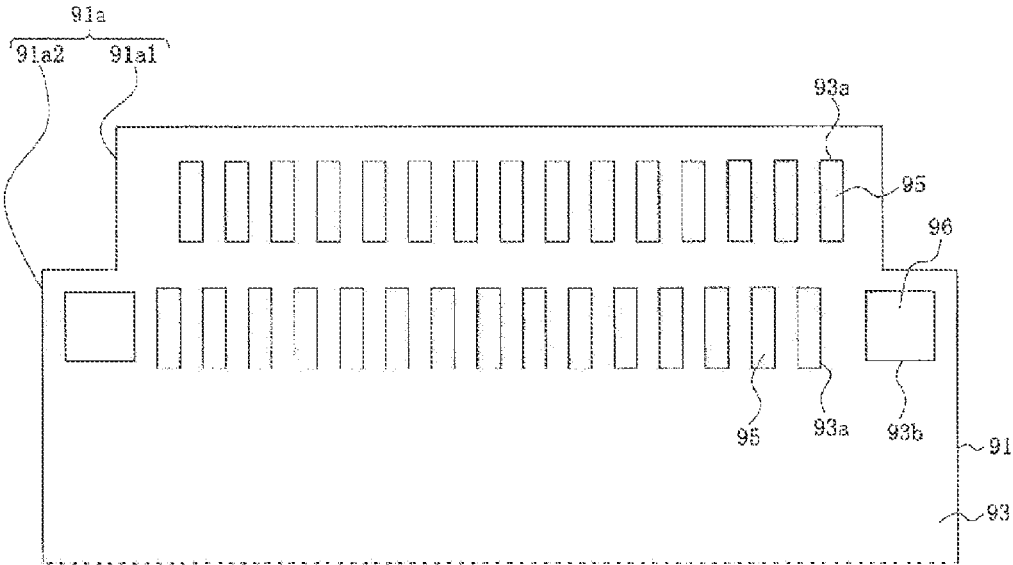


FIG. 7



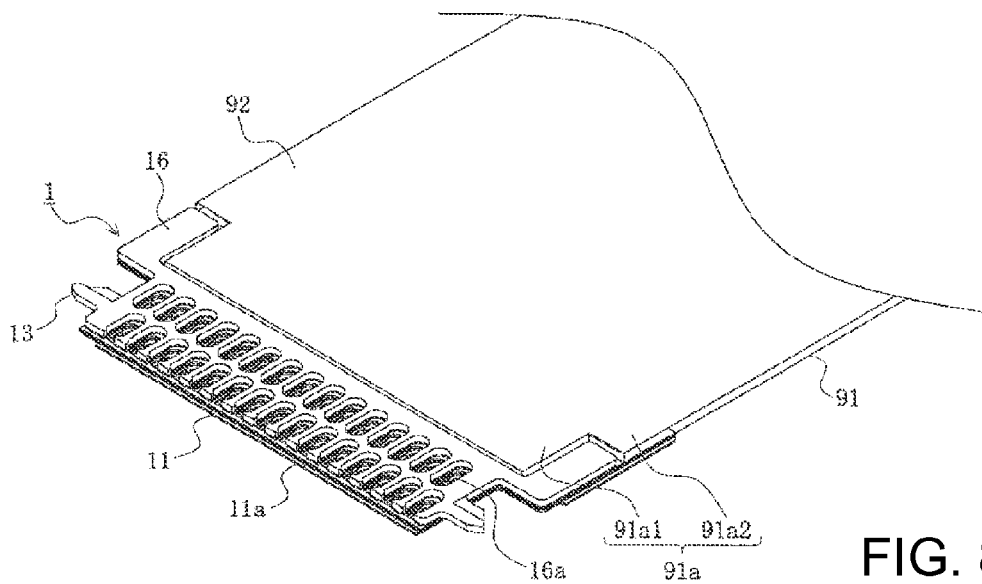


FIG. 8A

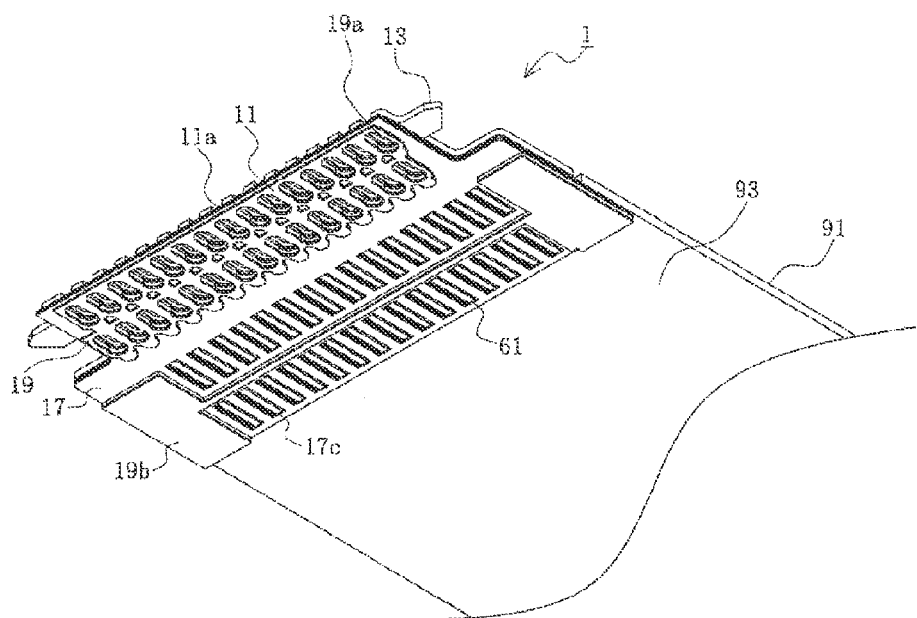


FIG. 8B

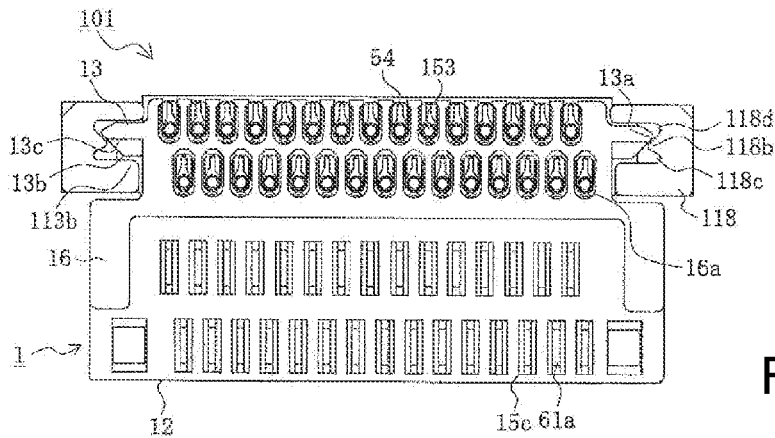


FIG. 9A

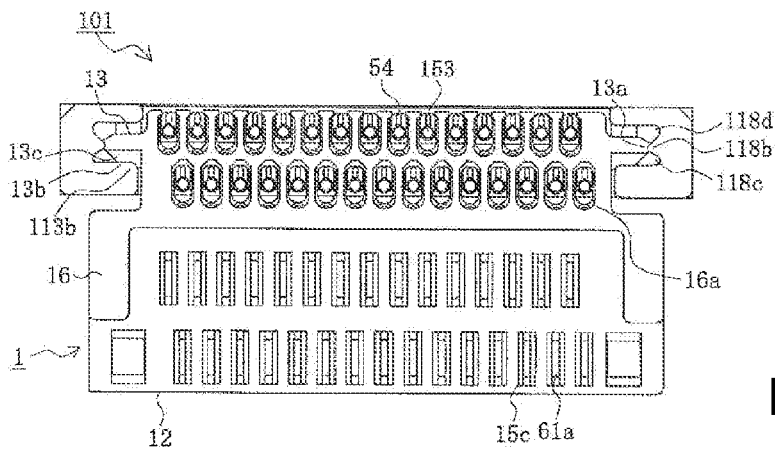


FIG. 9B

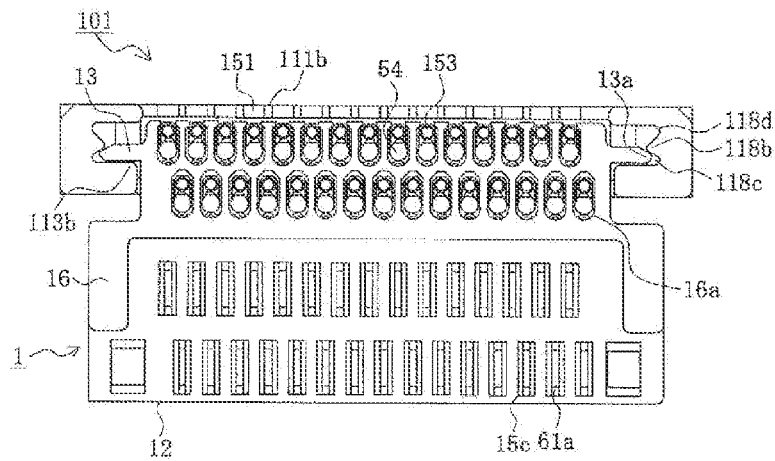


FIG. 9C

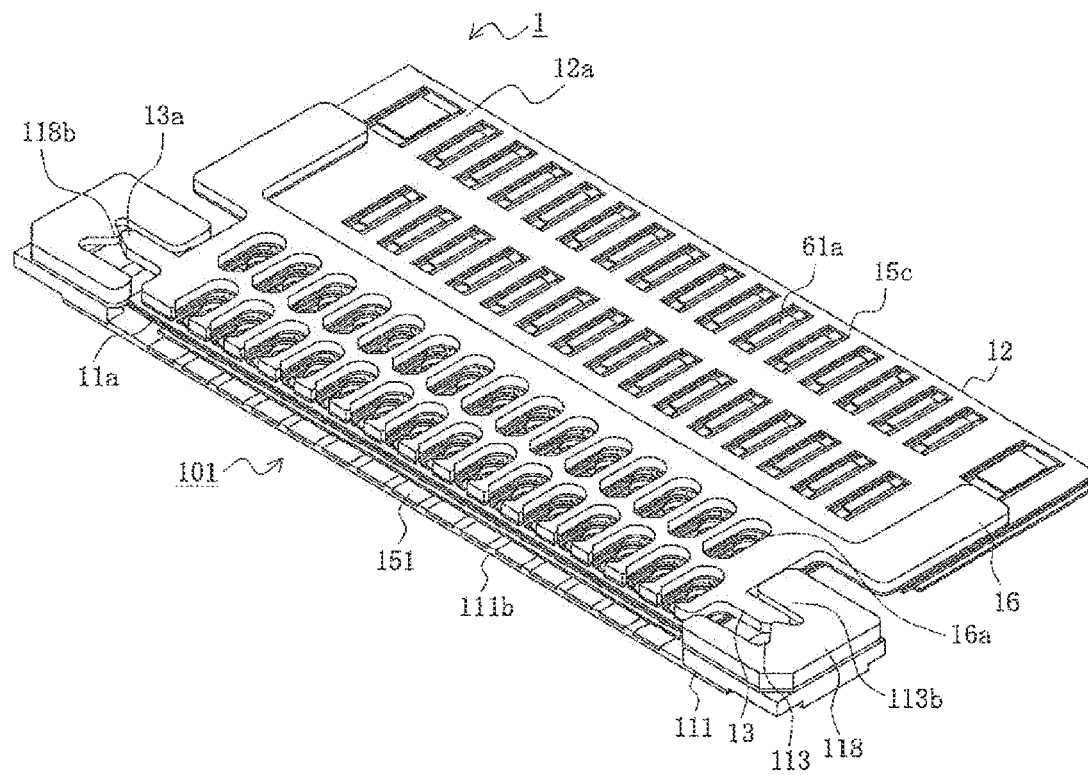
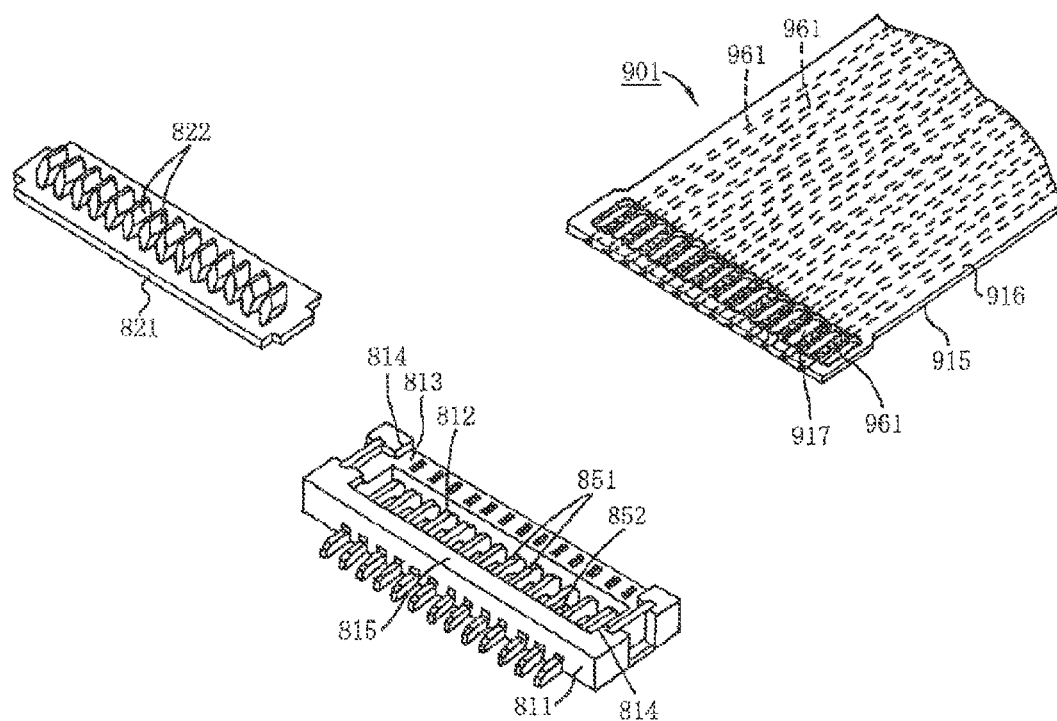


FIG. 10



Prior art

FIG. 11

## CONNECTOR

## REFERENCE TO RELATED APPLICATIONS

The Present Disclosure claims priority to prior-filed Japanese Patent Application No. 2013-102836, entitled "Connector," and filed with the Japanese Patent Office on 15 May 2013, the content of which is fully incorporated in its entirety herein.

## BACKGROUND OF THE PRESENT DISCLOSURE

The Present Disclosure relates, generally, to a connector.

Electronic devices typically use connectors to connect components mounted on a printed circuit board to a flat cable such as a flexible printed circuit (FPC). An example is disclosed in Japanese Patent Application No. 1994-302961, the content of which is fully incorporated in its entirety herein.

FIG. 11 is an exploded view of a typical conventional connector. In this drawing, **901** is a flexible circuit board including a plurality of conductors **961** formed by patterning copper foil formed on one surface of a resin sheet **915**. The upper surfaces of the conductors **961** are covered with resin film **916**. A plurality of through-holes **917** are also formed in the end portion of the flexible circuit board **901**. Each through-hole **917** is formed between adjacent conductors **961**. The resin film **916** is removed near the end portion to expose the conductors **961**.

Further, **811** is the housing of the connector used to connect the flexible circuit board **901** to a printed circuit board (not shown), and **851** denotes the terminals in the connector. One end of each terminal is soldered to a connector exposed on the surface of the printed circuit board. An opening **812** extending in the direction of the row of terminals **851** is formed in the housing **811** to expose the terminals **851** inside the opening **812**. A recessed portion **813** for accommodating an end of the flexible circuit board **901** is formed on the upper surface of the housing **811**. The three sides of the recessed portion **813** are formed by a front wall portion **815** and a pair of side wall portions **814**.

Also, **821** is a cover member with comb tooth guides **822** protruding on one side. Each comb tooth guide **822** is inserted into a space **852** between the terminals **851** exposed inside the opening **812**.

When the flexible circuit board **901** is connected to the connector, the end portion of the flexible circuit board **901** is inserted into the recessed portion **813** with the exposed conductors **961** facing the upper surface of the housing **811**. At this time, each of the exposed conductors **961** faces an exposed terminal **851** inside the opening **812**, and each through-hole **917** faces a space **852** between the terminals **851**. The cover member **821** is oriented so that the comb tooth guides **822** face the upper surface of the housing **811**, and is attached to the housing **811** above the flexible circuit board **901**. At this time, each comb tooth guide **822** passes through a through-hole **917** and is inserted into and engages with a space **852** between terminals **851**. In this way, the flexible circuit board **901** is pressed against the housing **811**, the conductors **961** make contact with the terminals **851**, and the flexible circuit board **901** is connected to the connector.

## SUMMARY OF THE PRESENT DISCLOSURE

In a typical conventional connector, the comb tooth guides **822** on the cover member **821** are inserted into and engage with the gaps **852** between exposed terminals **851** in the

opening **812**. Consequently, the height dimension of the housing **811** cannot be reduced, and the pitch between terminals **851** cannot be narrowed. This makes it difficult to lower the profile and more highly integrate electrodes as devices get smaller and more integrated.

It is an object of the Present Disclosure to solve the aforementioned problems by providing a reliable sheet connector in which protrusions are formed in the wiring lines connected to the conductive trace connecting portions of a flat cable, so that the flat cable can be connected more easily and reliably, can be manufactured more easily, and can be made more reliable even while making the configuration of the flat connector simpler, more integrated, more compact, and lower in profile.

The Present Disclosure discloses a connector having a flat cable connecting portion connected to a flat cable and a flat mating portion mated with another connector. The connector comprises a plurality of terminals arranged on the mating portion for establishing contact with terminals on the other connector, a conductive connecting portion exposed on the cable connecting portion and connected to conductive trace connecting portions on the flat cable, and a plurality of wiring lines extending from the mating portion to the cable connecting portion. Each wire connects a terminal to the corresponding conductive trace connecting portion. The conductive connecting portion having a protrusion formed on the wiring lines, and the upper surface of the protrusion being substantially the same height as one outer surface of the cable connecting portion.

In another connector of the Present Disclosure, the cable connecting portion has connecting portion accommodating openings passing through the cable connecting portion in the thickness direction, and each conductive connecting portion is exposed inside each connecting portion accommodating opening.

In another connector of the Present Disclosure, each connecting portion accommodating opening is wider than the conductive connecting portion.

In another connector of the Present Disclosure, the cable connecting portion includes insulating base film arranged on one surface of the wiring lines and an insulating cover film arranged on the other surface of the wiring lines; each connecting portion accommodating opening includes an opening passing through the insulating base film in the thickness direction and an opening passing through the insulating cover film in the thickness direction; and the upper surface of each protrusion is substantially the same height as the outer surface of the base film.

In another connector of the Present Disclosure, the conductive connecting portions are arranged side by side so as to form a plurality of rows extending in the width direction of the connector, and conductive connecting portions in adjacent rows are arranged so as to be staggered at half a pitch relative to each other in the thickness direction of the connector.

In the connector of the Present Disclosure, protrusions are formed in the wiring lines connected to the conductive trace connecting portions of a flat cable. In this way, the flat cable can be connected more easily and reliably, can be manufactured more easily, and can be made more reliable even while making the configuration of the flat connector simpler, more integrated, more compact, and lower in profile.

## BRIEF DESCRIPTION OF THE FIGURES

The organization and manner of the structure and operation of the Present Disclosure, together with further objects and advantages thereof, may best be understood by reference to

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the following Detailed Description, taken in connection with the accompanying Figures, wherein like reference numerals identify like elements, and in which:

FIG. 1 is a plan view of a female connector in an embodiment of the Present Disclosure, in which FIG. 1(a) is view of the connector from the side opposite the mated surface, and FIG. 1(b) is a diagram showing the connector from the side with the mated surface;

FIG. 2 is a perspective view of a male connector;

FIG. 3 is an exploded view showing the layered structure of the male connector of FIG. 2;

FIG. 4 is a simplified cross-sectional view of the female connector of FIG. 1, from Arrow A-A in FIG. 1;

FIG. 5 is an exploded view of the female connector of FIG. 1;

FIG. 6 is a diagram of the female connector of FIG. 1 from the side opposite the mated surface, in which FIG. 6(a) is a perspective view, and FIG. 6(b) is a perspective view of the wiring layer only;

FIG. 7 is a plan view showing the front end near the flat cable;

FIG. 8 is a diagram of the female connector of FIG. 1, connected to the front end of a flat cable, in which FIG. 8(a) is a perspective view of the female connector from the side opposite the mated surface, and FIG. 8(b) is a perspective view of the female connector from the side with the mated surface;

FIG. 9 is a plan view showing the mating operation for the male connector and the female connector, in which FIGS. 9(a) through (c) show each step in the mating operation;

FIG. 10 is a perspective view showing the mated male and female connectors; and

FIG. 11 is an exploded view of a conventional connector.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the Present Disclosure may be susceptible to embodiment in different forms, there is shown in the Figures, and will be described herein in detail, with the understanding that the Present Disclosure is to be considered an exemplification of the principles of the Present Disclosure, and is not intended to limit the Present Disclosure to that as illustrated.

In the Present Disclosure, directional representations—i.e., up, down, left, right, front, rear and the like, used for explaining the structure and movement of the various elements of the Present Disclosure, are relative. These representations are appropriate when the elements are in the position shown in the Figures. If the description of the position of the elements changes, however, it is assumed that these representations are to be changed accordingly.

Referring to the Figures, 101 is the second connector among the connectors of the Present Disclosure and is a male connector. This connector is mounted on a mounting member not shown in the drawings, and is connected electrically to the female connector 1 serving as the first connector described below. The mounting member can be any type of board commonly used in electronic devices. Examples include printed circuit boards, flexible flat cables (FFC), and flexible printed circuit boards. This is referred to simply as the board in the following explanation.

The male connector 101 that is the connector opposite the female connector 1 has a plate-like main body portion 111 with a rectangular planar shape. The main body portion 111 includes: a reinforcing layer 116 serving as a plate-like reinforcing portion, and is a flat, thin plate member on the mounted surface side (the side opposite the mated surface)

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(downward in FIGS. 2-3); a base film 115 serving as a male board portion, which is a plate-like second board portion or an insulating thin plate portion having a slender, band-like shape; and a conductive pattern 151 serving as a male conductive portion, which is a plate-like first conductive portion arranged on one surface of the base film 115 (the mated surface side). A plurality of conductive patterns 151 are separated by pattern separating space 152. The dimension of the main body portion 111 in the thickness direction is from 0.3 to 0.5 mm, but this dimension can be changed if necessary.

The base film 115 can be any material insulating material, including resins such as polyimide. A reinforcing layer 116 serving as a plate-like reinforcing portion is a flat, thin plate member provided on the other surface of the base film 115 (the surface on the mounted surface side). The reinforcing layer 116 is made of a metal such as stainless steel, but can also be made of some other material such as a resin or a composite material containing glass fibers or carbon fibers.

The conductive patterns 151 are formed, for example, by applying copper foil having a thickness ranging from several to several tens of  $\mu\text{m}$  on one surface of the base film 115 and then by patterning the copper foil using an etching process. Two separate rows are arranged in parallel along the front end 111a and the rear end 111b extending in the longitudinal direction of the main body portion 111, which is also the transverse direction of the male connector 101, and the adjacent conductive patterns 151 in each row are separated from each other and arranged at a predetermined pitch.

The row along the front end 111a and the row along the rear end 111b are arranged so as to be staggered one-half pitch with respect to the longitudinal direction of the main body portion 111. In other words, the conductive patterns 151 in the row along the front end 111a and the conductive patterns 151 in the row along the rear end 111b are arranged in a zigzag pattern staggered by one-half pitch with respect to the traverse direction (width direction) of the male connector 101.

Each conductive pattern 151 is a male connector and a first connector functioning as a plurality of conductive wires arranged in parallel. Each one is exposed on the mated surface of the main body portion 111, and has a single protruding terminal 153 serving as a male terminal and opposing terminal. In the example shown in the drawings, the conductive patterns 151 and the protruding terminals 153 are arranged in parallel to each other at a predetermined pitch, for example, 0.2 to 0.4 mm, so that two rows extend in the width direction of the main body portion 111. However, the number, pitch, and arrangement of conductive patterns 151 and protruding terminals 153 are not limited to the example shown in the drawings. They can be changed if necessary.

Each protruding terminal 153 is a member protruding from the surface of a conductive pattern 151, and is integrated with the conductive pattern 151, for example, by performing etching using the photolithographic technique. The dimension of the protruding terminals 153 in the height direction can range, for example, from 0.1 to 0.3 mm, but this can be changed if necessary.

Also, the dimension of the upper surface and transverse section of the protruding terminals 153 is preferably greater in the longitudinal direction than in the lateral direction. They preferably have a shape which has an inclined portion in the forward direction, for example, a hexagonal shape or a pentagonal shape similar to home plate in baseball with the point facing forward. However, the shape is not limited to the example shown in the drawing. It can be changed to any shape, such as a round or oval shape.

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The shape of the side surface of the protruding terminals **153** in the present embodiment is preferably concave as shown in FIG. 2. More specifically, in the protruding terminals **153**, the width dimension of the base end portion **153a**, which is the portion connected to the surface of the conductive patterns **151**, is greater than the width dimension of the front end portion **153b**, which is the upper end portion. The side surface portion **153c** between the base end portion **153a** and the front end portion **153b** is smooth for insertion inward in the width direction relative to the base end portion **153a** and the front end portion **153b**. The shape of the side surface portion **153c** is preferably a gradual, continuous curve. However, it may also be a curved surface consisting of a plurality of connected inclined surfaces.

Each conductive pattern **151** is connected electrically to the corresponding mounting pattern (not shown) which corresponds to the other surface of the base film **115** (the side with the mounting surface). The electrical connection can be established, for example, via a through-hole formed in the base film **115**. Each mounting pattern is connected via solder to a connection pad formed on the surface of the board serving as the mounting member. In this way, the male connector **101** can be mounted to the board, and the conductive patterns **151** and protruding terminals **153** can be connected electrically to connection pads on the board. Instead of mounting patterns, tail portions can be formed in each conductive pattern **151** which extend in the width direction of the main body portion **111** and protrude outward from the base film **115** so that the tail portions can be connected to the connection pads of the board.

A reinforcing metal fitting **156** is provided on one side of the conductive patterns **151**. The reinforcing metal fittings **156** are formed along with the conductive patterns **151** by applying copper foil having a thickness ranging from several to several tens of  $\mu\text{m}$  on one surface of the base film **115**, and then patterning the copper foil using etching so that the metal fittings extend in the traverse direction of the main body portion **111**, and are provided on both ends of the main body portion **111** in the longitudinal direction separated from the conductive patterns **151**.

In each reinforcing metal fitting **156** are formed a recessed portion **156a** for insertion of a connector engaging lug portion **13** of the female connector **1** as explained below, and a fixing lug portion **156b** extending to the outside in the longitudinal direction of the main body portion **111**. The bottom surface of the fixing lug portion **156b** is exposed on the mounting surface of the main body portion **111**, and the exposed portion is connected to a fixing pad formed on the surface of the board, for example, via soldering. In this way, the male connector **101** is secured to the board.

An engagement reinforcing plate **118**, which is a flat, plate-like engaging portion, is provided on the surface of the reinforcing metal fitting **156** (that is, on the mated surface). This engagement reinforcing plate **118** is made of metal, for example, stainless steel, but may also be made of a different type of material such as a resin or a composite containing glass fibers or carbon fibers. Also, an insertion recessed portion **118a** is formed in each engagement reinforcing plate **118** to insert a connector engaging lug portion **13** on the female connector **1**.

The engagement reinforcing plate **118** is securely bonded to the reinforcing metal fitting **156** via a flat spacer member **157**. Because the insertion recessed portion **118a** is arranged at a position corresponding to the recessed portion **156a**, as shown in FIG. 2, a connector engaging recessed portion **113** is formed to engage the connector engaging lug portion **13** of the female connector **1**. Because the dimensions of the inser-

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tion recessed portion **118a** are smaller than the dimensions of the recessed portion **156a**, an eave-like retaining portion **113b** and a retaining recessed portion **113a** covered by the retaining portion **113b** are formed near the front end **111a** of the main body portion **111** in the connector engaging recessed portion **113**.

A latching protrusion **118b** is formed on the side wall positioned to the inside of the connector engaging recessed portions **113** and the insertion recessed portion **118a** as another latching protrusion protruding towards the center of the male connector **101** in the width direction. The latching protrusion **118b** is flat with a triangular shape. The portions near the front end portion **111a** and the rear end portion **111b** of the latch protrusion **118b** in the insertion recessed portion **118a** become the front end latching recessed portion **118c** and the rear end latching recessed portion **118d**.

In the present embodiment, the female connector **1** is the first connector or the connector, and has a rectangular planar shape. It is connected electrically to the male connector **101** or the second connector. The female connector **1** may be mounted on a mounting member such as a printed circuit board, a flexible flat cable, or a flexible circuit board. In the present embodiment, it is connected to the end portion of a flat cable **91** such as a flexible flat cable or flexible circuit board described below.

In the example shown in the drawing, the female connector **1** has a flat cable connecting portion **12** connected to the flat cable **91**, and a flat main body portion **11** formed in or connected to the end of the cable connecting portion **12**. The main body portion **11** and the cable connecting portion **12** comprise, in order from the side opposite the mated surface (from the top in FIG. 5), the following: an engagement reinforcing plate **16** in the shape of a plate-like member serving as a reinforcing plate portion; a bonding layer **18** composed of an adhesive, a base film **15** serving as an insulating layer or female base portion, which is an insulating thin plate-like member shared with the cable connecting portion **12**; wiring lines **61**, which are conductive wires arranged in parallel rows on one side (the bottom side in FIG. 5) of the base film **15**; cover film **17**, which is an insulating layer serving as a plate-like female covering portion for covering the wiring lines **61** and as an insulating thin plate-like member shared with the cable connecting portion **12**; a plurality of flat terminals **51** serving as flat terminal members or female connectors; and a reinforcing layer **19** serving as a sheet-like insulating layer covering the flat terminals **51**.

A cable connection reinforcing layer **63** is arranged on both sides of the wiring lines **61** in the same layer as the wiring lines **61**. The flat terminals **51** are present only in the main body portion **11**, and a terminal reinforcing layer **56** is provided in the same layer of the flat terminals **51** in the cable connecting portion **12**. An auxiliary reinforcing layer **19b** is arranged in the same layer as the reinforcing layer **19** but in a position corresponding to the terminal reinforcing layer **56**.

The flat terminals **51** have a substantially flat oval shape and are separated by terminal separating spaces **52**. Each wiring line **61** is connected electrically to the corresponding conductive connecting pad **95** or conductive trace in the flat cable **91**. The dimension of the main body portion **11** in the thickness direction is approximately from 0.3 to 0.5 mm, but this dimension can be changed if necessary.

The base film **15** and cover film **17** can be made of any insulating material, including a resin such as polyimide. The engagement reinforcing plate **16**, reinforcing layer **19**, and auxiliary reinforcing layer **19b** are made of a metal such as

stainless steel, but can also be made of some other material such as a resin or a composite material containing glass fibers or carbon fibers.

The wiring lines **61** are formed, for example, by patterning (for example, etching) copper foil with a thickness from several to several tens of  $\mu\text{m}$  affixed to one side of the base film **15**, so as to arrange the wires in parallel at a predetermined pitch.

The flat terminals **51** are formed, for example, by patterning (for example, etching) copper foil with a thickness from several to several tens of  $\mu\text{m}$  affixed to one side of the cover film **17**, so as to arrange the terminals in a row along the front end **11a** of the main body portion **11** extending in the traverse direction (width direction) of the female connector **1** and a row formed near the cable portion **12**, and so that adjacent flat terminals **51** in the same row and adjacent rows are separated from each other and arranged at a predetermined pitch. The pitch is established so as to be equal to the pitch of the conductive pattern **151** in the male connector **101** and the pitch of the wiring lines **61**.

The row along the front end **11a** and the row near the cable connecting portion **12** are arranged so as to be staggered one-half pitch relative to the traverse direction of the female connector **1**. In other words, the flat terminals **51** in the row along the front end **11a** and the flat terminals **51** in the row near the cable connecting portion **12** are arranged so as to be staggered by one-half pitch relative to the traverse direction of the female connector **1**.

Each flat terminal **51** has an opening **54** serving as a protruding terminal accommodating opening having a bottle-shaped or spoon-shaped planar shape, and an arm portion **53** and terminal connecting hole **51a** serving as a first terminal member for demarcating the left and right sides of the opening **54**. Each opening **54** receives and accommodates a protruding terminal **153** on the male connector **101** when a flat terminal **51** is mated with the protruding terminal **153**. Each opening **54** has a circular or egg-shaped large-diameter portion **54a** and a passage-like small-diameter portion **54b** connected to the front end **11a** of the main body portion **11** in the large-diameter portion **54a** and extending towards the front end **11a**. The edge of the small-diameter portion **54b** on the front end **11a** of the main body portion **11** may be open or closed as shown in FIG. 5.

The large-diameter portion **54a** receives the protruding terminal **153** from the front end portion **153b**, and the dimensions of the inner portion are greater than the outer dimensions of the front end portion **153b** of the protruding terminal **153**. In this way, a protruding terminal **153** can be inserted smoothly into the opening **54** when the flat terminal **51** is mated with the protruding terminal **153**. The small-diameter portion **54b** allows the protruding terminal **153** inserted into the large-diameter portion **54a** to be slidably moved when the female connector **1** is slid to the rear relative to the male connector **101**.

The width dimensions of small-diameter portion **54b** are equal to or slightly smaller than the diameter or width dimension of the side portions **153c** of the protruding terminal **153**. As a result, when the protruding terminal **153** is moved into the small-diameter portion **54b**, both arm portions **53** come into contact with the side surface portions **153c** of the protruding terminal **153** and are elastically displaced. In other words, the interval between the arm portions is widened. Because the protruding terminal **153** receives pressure from the arm portions **53**, the electrical connection between the protruding terminal **153** and the flat terminal **51** remains reliable.

A terminal accommodating opening **19a** is formed in the reinforcing layer **19** in a position corresponding to the opening **54** in each flat terminal **51**. The terminal accommodating openings **19a** are arranged in two rows so as to be staggered at half a pitch from each other similar to the flat terminals **51**. The terminal accommodating openings **19a** pass through the reinforcing layer **19** in the thickness direction. The terminal accommodating openings **19a** have an oval or round planar shape, and are larger in size than the openings **54** but smaller in size than the external shape of the flat terminals **51**.

A terminal accommodating opening **17a** and a through-hole **17b** are formed in the cover film **17** in positions corresponding to the opening **54** and terminal connecting hole **51a** for each flat terminal **51**. In other words, the terminal corresponding holes **17a** and through-holes **17b** are arranged in two rows so as to be staggered at half a pitch from each other similar to the flat terminals **51**. The terminal accommodating openings **17a** and the through-holes **17b** pass through the cover film **17** in the thickness direction. The terminal accommodating openings **17a** have an oval or round planar shape, and are larger in size than the openings **54** and smaller in size than the external shape of the flat terminals **51**. Wiring line accommodating openings **17c** are formed in the portion of the cover film **17** corresponding to the cable connecting portion **12** and are openings passing through the cover film **17** in the thickness direction in positions corresponding to the connecting protrusions **61a** of each wiring line **61**. The surface on the mating surface for the corresponding wiring line **61** is exposed in each wiring line accommodating opening **17c**. As shown in FIG. 1(b), the wiring line accommodating openings **17c** are preferably wider than the corresponding wiring lines **61** and longer than the connecting protrusions **61a**.

A substantially rounded connecting end portion **62** is formed on the tip of each wiring line **61**, and a wiring line connecting hole **62a** is formed in each connecting end portion **62**. The wiring line connecting holes **62a** are centered on the wiring lines **61**, and pass through the wiring lines **61** in the thickness direction. The connecting protrusions **61a** are formed on the side opposite the mating surface of each wiring line **61**, and are connected as a conductive connecting portion to the connecting pads **95** serving as the conductive trace connecting portions of the flat cable **91**. As shown in FIG. 4, the connecting protrusions **61a** are thick protrusions formed integrally with the wiring lines **61** using etching, and protrude from the surface opposite the mating surfaces of the wiring lines **61**. The surface opposite the mating surface is preferably substantially the same height as the surface of the base film **15** opposite the mating surface. Each wiring line **61** is positioned so the wiring line connecting hole **62a** is aligned with a terminal connecting hole **51a** in a flat terminal **51** and a through-hole **17b** in the cover film **17**, and so the connecting protrusion **61a** is aligned with a wiring line accommodating opening **17c** in the cover film **17**.

A reinforcing protrusion **63a** is formed on the surface of the cable connection reinforcing film **63** on the side opposite the mating surface on both the left and right ends of the wiring lines **61**. This serves as a connection reinforcing portion which is connected to a reinforcing pad **96** of the flat cable **91**. Each reinforcing protrusion **63a** is integrally formed with the cable connection reinforcing layer **63** using etching, and protrudes from the surface of the cable connection reinforcing layer **63**.

The terminal connecting hole **51a** in each flat terminal **51** on the lower surface of the cover film **17**; that is, the layer on the mated side is connected electrically to the wiring line connecting hole **62** of the corresponding wiring line **61** on the upper surface of the cover film **17**; that is, in the layer opposite



the mated side via the conductive material in a through-hole 17b. In other words, the flat terminals 51 and wiring lines 61 are arranged in different layers of the female connector 1 and are connected electrically via a conductive material.

The connecting end portions 62 and wiring line connecting holes 62a of the wiring lines 61 are arranged in two rows so as to be staggered at half a pitch from each other similar to the flat terminals 51. Accordingly, the connecting protrusions 61a are also arranged in two rows so as to be staggered at half a pitch from each other. In other words, the wiring lines 61 are arranged so that the long wiring lines 61 with a connecting end portion 62 and connecting protrusion 61a at the tip closer to the front end 11a of the main body portion 11 alternate with the short wiring lines 61 with a connecting end portion 62 and connecting protrusion 61a at the tip farther from the front end 11a of the main body portion 11. The long wiring lines 61 pass between adjacent flat terminals 51 in the row closer to the cable connecting portion 12 when viewed from above.

A terminal accommodating opening 15a is formed in the base film 15 for the opening 54 of each flat terminal 51. In other words, the terminal accommodating openings 15a are also arranged in two rows so as to be staggered at half a pitch from each other similar to the flat terminals 51. The terminal accommodating openings 15a have an oval or round planar shape, and are larger in size than the openings 54 but smaller in size than the external shape of the flat terminals 51. The wiring line accommodating openings 15c are formed in the portion of the base film 15 corresponding to the cable connecting portion 12 so as to align with the connecting protrusion 61a of each wiring line 61. These openings 15c pass through the base film 15 in the thickness direction. Each wiring line accommodating opening 15c exposes a thick connecting protrusion 61a of a wiring line 61 formed on the surface opposite the mated surface. The surface of the connecting protrusions 61a on the surface opposite the mated surface is preferably substantially the same height as the surface of the base film 15 opposite the mated surface. The connecting protrusions 61a are connected to the connecting pads 95 of the flat cable 91 using a means such as soldering. As shown in FIG. 1(a), the wiring line accommodating opening 15c is preferably wider than the corresponding wiring line 61 and longer than the connecting protrusion 61a.

A plurality of connecting portion accommodating openings 12c are formed so as to pass through the cable connecting portions 12 along with the wiring line accommodating openings 15c and the wiring line accommodating openings 17c of the cover film 17. The connecting portion accommodating openings 12c are wider than the connecting protrusions 61a.

A reinforcing protrusion accommodating opening 15b is formed on both the left and right sides of the wiring line accommodating openings 15c in the base film 15 so as to align with the reinforcing protrusions 63a on the cable connection reinforcing layer 63. Each of the reinforcing protrusion accommodating openings 15b exposes a reinforcing protrusion 63a on the cable connection reinforcing layer 63, and the surface of the reinforcing protrusions 63a are preferably substantially the same height as the surface of the base film 15 opposite the mated surface.

Terminal accommodating openings 16a are also formed in the engagement reinforcing plate 16 so as to be aligned with the openings 54 in each flat terminal 51. In other words, the terminal accommodating openings 16a are arranged in two rows so as to be staggered at half a pitch from each other similar to the flat terminals 51. The terminal accommodating openings 16a pass through the engagement reinforcing plate 16 in the thickness direction. The terminal accommodating openings 16a have an oval or round planar shape, and are

larger in size than the openings 54 but smaller in size than the external shape of the flat terminals 51. A pair of arm portions 16b extend to the rear in the portion of the engagement reinforcing plate 16 corresponding to the cable connecting portion 12. The connection recessed portion 12a on the surface of the cable connecting portion 12 opposite the mated surface is defined on three sides by the engagement reinforcing plate 16. The front end portion 91a of the flat cable 91 described below is accommodated inside the connecting recessed portion 12a.

Terminal accommodating openings 18a are formed in the bonding layer 18 on the surface of the engagement reinforcing plate 16 opposite the mated surface so as to be aligned with the opening 54 in each flat terminal 51. In other words, the terminal accommodating openings 18a are arranged in two rows so as to be staggered at half a pitch from each other similar to the flat terminals 51. The terminal accommodating openings 18a pass through the bonding layer 18 in the thickness direction. The terminal accommodating openings 18a have an oval or round planar shape, and are larger in size than the openings 54 but smaller in size than the external shape of the flat terminals 51. A pair of arm portions 18b extend to the rear in the portion of the bonding layer 18 corresponding to the cable connecting portion 12 as in the case of the engagement reinforcing plate 16.

A connector engaging lug portion 13 extending to the outside of the female connector 1 is formed on both the left and right sides of the engagement reinforcing plate 16 in the portion corresponding to the main body portion 11. When the female connector 1 is mated with the male connector 101, the connector engaging lug portion 13 engages the connector engaging recessed portion 113 in the male connector 101 to keep the female connector 1 from becoming detached from the male connector 101.

An inserted retaining portion 13c and an eave-like retaining portion 13b covering the retaining portion 13c are formed on the rear end of the connector engaging lug portion 13 (the end with the cable connecting portion 12). When the connector engaging lug portion 13 is engaged with the connector engaging recessed portion 113 and slides further towards the front end 111a of the male connector 101 than the female connector 1 in the male connector 101, the retaining protrusion 13b and the retaining portion 13c engage the retaining recessed portion 113a and the retaining portion 113b in the connector engaging recessed portion 113, and the connector engaging lug portion 13 is kept from becoming detached from the connector engaging recessed portion 113.

A latching protrusion 13a is formed in the connector engaging lug portion 13 which protrudes to the outside in the width direction of the female connector 1. The latching protrusion 13a has a triangular planar shape, and is able to engage the front end latching recessed portion 118c and rear end latching recessed portion 118d in the insertion recessed portion 118a of the male connector 101.

The terminal accommodating openings 15a, reinforcing protrusion accommodating openings 15b and wiring line accommodating openings 15c in the base film 15 as well as the terminal accommodating openings 17a, the through-holes 17b and the wiring line accommodating openings 17c in the cover film 17 can be created by etching the base film 15 and the cover film 17 using an alkaline etchant.

In the present embodiment, the flat cable 91 is a flexible circuit board or flexible flat cable. However, any type of cable can be used. It can even be rigid instead of flexible. The flat cable 91 has a base film 92, which is a thin, slender insulating sheet serving as the sheet-like base portion, and a cover film 93, which is a thin, slender insulating sheet serving as the sheet-like covering portion used to cover the rows of conduc-

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tive traces (not shown) and the entire surface of the base film 92 containing the conductive traces (the lower surface in FIG. 8(a)). In other words, the flat cable 91 is a flat member with a layered structure in which the base film 92, conductive traces, and cover film 93 have been laminated in successive order.

The conductive traces are foil-like linear bodies made of a conductive material such as copper which are arranged in parallel at a predetermined pitch with respect to each other. The number, pitch and arrangement of the conductive traces is identical to those of the wiring lines 61 in the female connector 1. These can be changed if necessary. The flat cable 91 is a long, slender member, but the rear portion (below in FIG. 7) has been removed from the drawing for the sake of simplicity.

The base film 92 and the cover film 93 are made of a resin such as polyimide, but can be made of any other type of insulating material. The conductive traces can be formed by applying copper foil on one surface of the base film 92 to a thickness of several or several tens of  $\mu\text{m}$  and then etching and patterning the copper foil.

The front end portion 91a of the flat cable 91 has a wide portion 91a2 which is the same width as the rest of the cable, and a narrow portion 91a1 which is narrower than the wide portion 91a2 and which extends forward from the wide portion 91a2. Connecting pad accommodating openings 93a are formed in the portion of the cover film 93 corresponding to the front end portion 91a so as to be aligned with the connecting portion accommodating openings 12c formed in the cable connecting portion 12 of the female connector 1. Each of the connecting pad accommodating openings 93a exposes a connecting pad 95 serving as a conductive trace connecting portion.

Each of the connecting pads 95 is the portion of each conductive trace that is exposed by a connecting pad accommodating opening 93a and that is connected to the connecting protrusion 61a of a wiring line 61 in the female connector 1. The connecting pads 95 are preferably wider than the rest of the conductive trace. Also, because the cover film 93 is very thin, the surface of the exposed connecting pads 95 should be the same height as the surface of the cover film 93.

The connecting pad accommodating openings 93a and the connecting pads 95 are arranged in two rows so as to be staggered by half a pitch. More specifically, the row in narrow portion 91a1 and the row in the wide portion 91a2 are arranged so as to be staggered by half a pitch relative to the width direction of the flat cable 91. The conductive traces formed by the connecting pads 95 in the narrow portion 91a1 pass between adjacent connecting pads 95 in the row in the wide portion 91a2 when viewed from above.

A reinforcing pad accommodating opening 93b is formed on both the left and right sides of the connecting pads 95 in the wide portion 91a2 of the cover film 93, and a reinforcing pad 96 is exposed in each reinforcing pad accommodating opening 93b. Each reinforcing pad 96 exposed in the reinforcing pad accommodating opening 93b is a portion of the grand lines (not shown) in the flat cable 91, and is connected to the reinforcing protrusion 93a in the cable connection reinforcing layer 63 of the female connector 1. The reinforcing pads 96 are preferably wider than the other portion of the grand lines. Because the cover film 93 is very thin, the surface of the exposed reinforcing pads 96 is preferably substantially the same height as the cover film 93.

When a flat cable 91 is connected to the female connector 1, first, as shown in FIG. 7, the surface in the front end portion 91a of the flat cable 91 in which the connecting pads 95 are exposed faces the surface of the cable connecting portion 12 of the female connector 1 opposite the mated surface. As

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shown in FIG. 8(a), the front end portion 91a of the flat cable 91 is accommodated inside the connecting recessed portion 12a of the cable connecting portion 12 of the female connector 1. The connecting pads 95 and the connecting protrusion 61a on the corresponding wiring lines 61 are connected using solder, and the reinforcing pads 96 and the reinforcing protrusions 63a on the cable connection reinforcing layer 63 are also connected using solder. More specifically, solder paste is applied beforehand to the surfaces of the connecting pads 95 and reinforcing pads 96 or to the surfaces of the connecting protrusions 61a or reinforcing protrusions 63a, and the front end portion 91a of the flat cable 91 is soldered using the reflow of heated solder housed inside the connecting recessed portion 12a of the cable connecting portion 12 of the male connector 1. In this way, the flat cable 91 is connected to the female connector 1 as shown in FIGS. 8(a)-(b).

In the present embodiment, the connecting protrusions 61a and the reinforcing protrusions 63a protrude towards the surface opposite the mated surface. Consequently, the surfaces of the connecting protrusions 61a and the reinforcing protrusions 63a come close to or make contact with the surfaces of the corresponding connecting pads 95 and reinforcing pads 96 with the front end portion 91a of the flat cable 91 housed inside the connecting recessed portion 12a of the cable connecting portion 12 of the female connector 1. Because of this configuration, the connecting protrusions 61a and the reinforcing protrusions 63a can be reliably soldered and firmly secured to the connecting pads 95 and reinforcing pads 96. In this way, a reliable connection is established between each wiring line 61 and corresponding conductive trace. The physical connection between the flat cable 91 and the female connector 1 is also reliable and secure.

Because, as shown in FIG. 6(a), a recessed portion is formed around each connecting protrusion 61a aligned with a wiring line accommodating opening 15c or connecting portion accommodating opening 12c, the excess solder remains inside the recessed portion even when a large amount of molten solder is used. This keeps the molten solder from flowing towards other components. This reliably prevents shorts caused by solder flowing between adjacent connecting protrusions 61a or connecting pads 95.

Because, as shown in FIG. 8(b), a wiring line accommodating opening 17c is formed in the cover film 17 for each connecting protrusion 61a, the solder connections between the connecting protrusions 61a and the connecting pads 95 are visible from the mated surface of the female connector 1 via the wiring line accommodating openings 17c. This allows the connections between the connecting protrusions 61a and the connecting pads 95 to be visually inspected.

Also, as shown in FIG. 8(a), the outer surface of the base film 92 and the surface of the engagement reinforcing plate 16 of the female connector 1 opposite the mated surface are substantially flush with the front end portion 91a of the flat cable 91 accommodated inside the connecting recessed portion 12a of the cable connecting portion 12 of the female connector 1. As a result, the female connector 1 has a lower profile when the flat cable 91 is connected.

In operation, the operator holds the mated surface of the male connector 101 (the upper surface in FIG. 2) opposite the mated surface of the female connector 1 (the surface shown in FIG. 1(b)), lowers the female connector 1 towards the male connector 101 in the mating direction, and brings the mated surface of the male connector 101 closer to or into contact with the mated surface of the female connector 1.

With this, as shown in FIG. 9(a), the left and right connector engaging lug portions 13 of the female connector 1 enter the left and right connector engaging recessed portions 113 of

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the male connector **101**, and each protruding terminal **153** of the male connector **101** enters the large diameter portion **54a** of the opening **54** in the corresponding flat terminal **51** of the female connector **1**.

Depiction of the flat cable **91** has been omitted from FIGS. 9-10 for the sake of simplicity.

Because the inner dimensions of the connector engaging recessed portions **113** are greater than the outer dimensions of the connector engaging lug portions **13**, the connector engaging lug portions **13** can enter the connector engaging recessed portions **113** smoothly. Also, because the inner dimensions of the rear end latching recessed portions **118d** positioned to the inside of the connector engaging recessed portions **113** are larger than the outer dimensions of the latching protrusions **13a** at the front end of the connector engaging lug portions **13**, the latching protrusions **13a** can smoothly enter the rear end latching recessed portions **118d**. Because the inner dimensions of the large diameter portion **54a** are larger than the outer dimensions of the front end portion **153b** of the protruding terminals **153**, the protruding terminals **153** can smoothly enter the large diameter portion **54a**.

Next, the operator slides the female connector **1** relative to the male connector **101** in the direction of the front end **111a** of the male connector **101**. In other words, the female connector **1** is moved relative to the male connector **101** in the direction of the front of the male connector **101** with the mated surface of the male connector **101** and the mated surface of the female connector **1** either making contact or close to making contact.

With this, as shown in FIG. 9(b), the rear inclined surface of the latching protrusion **13a** on the front end of both the left and the right connector engaging lug portions **13** comes into contact with the rear inclined surface of the latching protrusion **118b** near the front end **111a** of the rear end latching recessed portion **118d**. Next, when the operator moves the female connector **1** relative to the male connector **101** towards the front of the male connector **101**, the latching protrusions **13a** of the female connector **1** and/or the latching protrusions **118b** of the male connector **101** are elastically deformed, and the latching protrusions **13a** of the female connector **1** ride up over the latching protrusions **118b** of the male connector **101** and easily enter the front end latching recessed portions **118c** as shown in FIG. 9(c). When the latching protrusions **13a** of the female connector **1** ride up over the latching protrusions **118b** of the male connector **101**, the elastic deformation of the latching protrusions **13a** of the female connector **1** and/or the latching protrusions **118b** of the male connector **101** generates a rebound. It may also generate vibrations or a noise. The operator can sense this rebound via the vibrations and/or the sound of a click.

The protruding terminals **153** positioned inside the large diameter portion **54a** of the openings **54** in the flat terminals **51** move towards the small diameter portion **54b**. When the protruding terminals **153** enter the small diameter portion **54b**, both arm portions **53** come into contact with the side surfaces **153c** of the protruding terminals **153**, and are elastically deformed. In other words, the space between them is widened. Consequently, the protruding terminals **153** are subjected to pressure from the arm portions **53**, and a reliable electrical connection is maintained between the protruding terminals **153** and the flat terminals **51**.

When the male terminal **101** and the female terminal **1** have been mated in this way, as shown in FIG. 9(c) and FIG. 10, the retaining protrusions **13b** and the retaining portions **13c** of the connector engaging lug portions **13** engages the retaining recessed portions **113a** and the retaining portions **113b** of the connector engaging recessed portions **113** and are retained.

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This keeps the connector engaging lug portions **13** from becoming detached from the connector engaging recessed portion **113**, and the mated male connector **101** and female connector **1** are reliably kept from becoming disengaged.

The latching protrusions **13a** are inserted into the front end latching recessed portions **118c** where they are engaged and secured. Because the female connector **1** can no longer slide relative to the male connector **101** in the direction of detachment, the retaining protrusions **13b** and the retaining portions **13c** of the connector engaging lug portions **13** and the retaining recessed portions **113a** and the retaining portions **113b** of the connector engaging recessed portions **113** are reliably kept from becoming disengaged.

The operations performed to detach the mated male connector **101** and female connector **1** are the exact opposite of the operations performed to mate the male connector **101** with the female connector **1**, so further explanation has been omitted.

In the explanation of the present embodiment, there were two rows of conductive patterns **151** and plate-like terminals **51**. However, the number of rows is not limited to two. There can be more rows than this. The conductive patterns **151** in one row and the conductive patterns **151** in an adjacent row may be staggered with respect to the width direction of the main body portion **111**, or the flat terminals **51** in one row and the flat terminals **51** in an adjacent row may be staggered in the width direction of the main body portion **11**.

The female connector **1** in the present embodiment has a flat cable connecting portion **12** connected to a flat cable **91**, and a flat main body portion **11** engaging the male connector **101**. It also has a plurality of flat terminals **51** arranged on the main body portion **11** and making contact with the protruding terminals **153** of the male connector **101**, a plurality of connecting protrusions **61a** exposed in the cable connecting portion **12** and connected to the connecting pads **95** of the flat cable **91**, and a plurality of wiring lines **61** extending from the main body portion **11** to the cable connecting portion **12** and electrically connecting each connecting protrusion **61a** to the corresponding flat terminal **51**. The connecting protrusions **61a** are protrusions formed on the wiring lines **61**, and the upper surface of the connecting protrusions **61a** is the same height as the outer surface of the cable connecting portion **12**.

Therefore, when the flat cable **91** is connected to the cable connecting portion **12**, the upper surface of the connecting protrusions **61a** can come close to or make contact with the connecting pads **95** of the flat cable **91**, and the connecting protrusions **61a** and the connecting pads **95** can be reliably connected using solder. Therefore, the flat cable **91** can be connected more easily and reliably, can be manufactured more easily, and can be made more reliable even while making the configuration of the female connector **1** simpler, more integrated, more compact, and lower in profile.

Also, the cable connecting portion **12** has a plurality of connecting portion accommodating openings **12c** passing through in the thickness direction, and each connecting protrusion **61a** is exposed inside each connecting portion accommodating opening **12c**. Therefore, the solder connection between the connecting protrusions **61a** and the connecting pads **95** can be visually inspected from the outside of the cable connecting portion **12** via the connecting portion accommodating openings **12c**.

The connecting portion accommodating opening **12c** is also wider than the connecting protrusions **61a**. As a result, the remaining solder can be accommodated inside the connecting portion accommodating opening **12c** surrounding the connecting protrusions **61a** even when the amount of molten solder is increased. This stops the remaining solder from

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flowing towards surrounding components, and keeps adjacent connecting protrusions 61a or connecting pads 95 from being shorted by the flowing solder.

Also, the cable connecting portion 12 includes insulating base film 15 arranged on one surface of the wiring lines 61 and an insulating cover film 17 arranged on the other surface of the wiring lines 61; each connecting portion accommodating opening 12c includes a wiring line accommodating opening 15c passing through the insulating base film in the thickness direction and a wiring line accommodating opening 17c passing through the insulating cover film 17 in the thickness direction; and the upper surface of each connecting protrusion 61a is substantially the same height as the outer surface of the base film 15. As a result, the space between adjacent connecting protrusions 61a is reliably insulated by the base film 15 and the cover film 17 to prevent shorting even while simplifying the configuration of the cable connecting portion 12.

Also, the conductive connecting protrusions 61a are arranged side by side so as to form a plurality of rows extending in the width direction of the female connector 1, and conductive connecting protrusions 61a in adjacent rows are arranged so as to be staggered at half a pitch relative to each other in the thickness direction of the connector 1. As a result, the pitch of the wiring lines 61 can be narrowed and the wiring lines 61 integrated more densely while also maintaining space between adjacent connecting protrusions 61a exposed in the cable connecting portion 12 to prevent shorting.

While a preferred embodiment of the Present Disclosure is shown and described, it is envisioned that those skilled in the art may devise various modifications without departing from the spirit and scope of the foregoing Description and the appended Claims.

What is claimed is:

1. A connector having a flat cable connecting portion connected to a flat cable and a flat mating portion mated with another connector, the connector comprising:

a plurality of terminals arranged on the mating portion for establishing contact with terminals on the other connector;

a conductive connecting portion exposed on the cable connecting portion and connected to conductive trace connecting portions on the flat cable, and

a plurality of wiring lines extending from the mating portion to the cable connecting portion, each one electrically connecting a terminal to the corresponding conductive trace connecting portion;

wherein the conductive connecting portion having a protrusion formed on the wiring lines, and the upper surface of the protrusion being substantially the same height as one outer surface of the cable connecting portion.

2. The connector of claim 1, wherein the cable connecting portion has connecting portion accommodating openings

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passing through the cable connecting portion in the thickness direction, and each conductive connecting portion is exposed inside each connecting portion accommodating opening.

3. The connector of claim 2, wherein each connecting portion accommodating opening is wider than the conductive connecting portion.

4. The connector of claim 3, wherein the cable connecting portion includes insulating base film arranged on one surface of the wiring lines and an insulating cover film arranged on the other surface of the wiring lines.

5. The connector of claim 4, wherein each connecting portion accommodating opening includes an opening passing through the insulating base film in the thickness direction and an opening passing through the insulating cover film in the thickness direction.

6. The connector of claim 5, wherein the upper surface of each protrusion is substantially the same height as the outer surface of the base film.

7. The connector of claim 6, wherein the conductive connecting portions are arranged side by side so as to form a plurality of rows extending in the width direction of the connector.

8. The connector of claim 7, wherein conductive connecting portions in adjacent rows are arranged so as to be staggered at half a pitch relative to each other in the thickness direction of the connector.

9. The connector of claim 1, wherein the conductive connecting portions are arranged side by side so as to form a plurality of rows extending in the width direction of the connector.

10. The connector of claim 9, wherein conductive connecting portions in adjacent rows are arranged so as to be staggered at half a pitch relative to each other in the thickness direction of the connector.

11. The connector of claim 2, wherein the conductive connecting portions are arranged side by side so as to form a plurality of rows extending in the width direction of the connector.

12. The connector of claim 11, wherein conductive connecting portions in adjacent rows are arranged so as to be staggered at half a pitch relative to each other in the thickness direction of the connector.

13. The connector of claim 3, wherein the conductive connecting portions are arranged side by side so as to form a plurality of rows extending in the width direction of the connector.

14. The connector of claim 13, wherein conductive connecting portions in adjacent rows are arranged so as to be staggered at half a pitch relative to each other in the thickness direction of the connector.

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